§3. High Current Application of HTS at NIFS

Kovachev, V. (Bulgarian Academy of Sciences)

Projects for high current application of high temperature superconductivity (HTS) are at the frontline of the modern applied superconductivity since HTS devices are having certain advantages to those made of conventional superconductors. These projects are also important because they demonstrate how HTS materials can eventually be used on wide bases for power industry purposes.

R & D for a number of interesting HTS application is carried out at NIFS:

(1) A joint research with Tokai University [1] for development of HTS current leads using Bi-2212 diffusion layer. The samples are prepared by original technology of diffusion reaction between Sr-Ca-Cu oxide tube as a substrate and Bi-Cu oxide with some Ag in it as a coating layer. The Bi-2212 layer obtained is about 150 microns thick, dense, textured with plate-like grains and has critical current density of 2×10^4 A/cm^2 at 4.2 K and self-field. The transport critical current of a tube (outer/inner diameter 20/16 mm) is estimated to be 4000 A at 4.2 K and self-field. Besides the end regions of tube samples are covered by layer of Ag precipitates which makes possible a reduction of the contact resistance, a good contact with low dissipation at high current is still a problem for testing real current capacity of Bi-2212 diffusion layer tubes.

(2) A joint project of NIFS and Institute for Technical Physics, Karlsruhe, Germany [2]. The final goal of this project is to develop a 60 kA HTS current lead for ITER toroidal field coils and for replacing the existing conventional leads in the superconducting coil test facility TOSKA at the Research Center in Karlsruhe. At present researchers involved in the project are focusing on the recent test results of a model current lead consisting of two 10 kA HTS modules connected in parallel. The test was successfully conducted at NIFS due to a tremendous effort of members of Superconductivity & Cryogenics group. Each module is made of two stacks composed of a number of Bi-2223 tapes with Ag/Au matrices sintered together. The stacks are soldered on the outer surface of a stainless steel support tube connected at both ends to copper end caps. Furthermore, to make a 20 kA current lead two parallel 10 kA modules are connected to a copper heat exchanger by means of a screw joint. Generally speaking the test results have shown that the large number of joints used in the 20 kA HTS current lead are having variety of contact resistance which causes unpredictable dynamic current distribution versus the load current. The test has shown that at about 60 K this current lead can be loaded with 40 kA for 10 s without problem either in the heat exchanger part or in the HTS one. However prior to proceed further with the R &D important decisions shall be made how to make different high current joints in more reproducible manner or perhaps how to reduce the number of necessary joints increasing the current carrying capacity of individual stacks, modules, and etc.

(3) Feasibility studies of a short current lead (feeder) made of bulk melt-textured YBCO material are also carried out at NIFS [3]. The feeder will be used in upgraded superconducting bus system for the LHD Phase II operation for current feeding between 4.2 K and 1.8 K. Melt-textured Y-based HTS is used for samples preparation because of higher critical current densities in comparison to those for Bi- HTS compounds. The recent test carried out as well as previous ones have revealed that the material and the feeder design used so far are very sensitive to overheating or eventual temperature gradient which easily can cause mechanical failure of the feeder.

(4) The next project related to application of HTS is feasibility study of levitating coils for a toroidal plasma confinement device [4]. The first step of this joint project with Tokyo University is to make a small HTS levitating coil. Such a coil is designed and will be made using state-of-the art Bi-2223 HTS. A HTS levitating coil could provide opportunities for achieving high power and/or long pulse plasma heating experiments due to larger temperature margin and larger heat capacity of HTS coils in comparison with conventional superconducting coils. Furthermore higher cooling efficiency and lower operational cost will be achieved. It is worth emphasizing that such a levitating coil made of HTS is a unique one.

A successful accomplishment of all these projects will be very beneficial to NIFS and to the large-scale application of HTS superconductivity as a whole.

References

1) Y. Yamada, et al., IEEE Trans. Appl. Supercon. 10 (2000) pp. 1481-1484.
2) R. Heller, et al., Test Report at NIFS, July 2000.
3) T. Mito, et al., J. Nucl. Materials, 258-263 (1998) pp. 1940-1945.
4) N. Yanagi, private communication.